

Summary

In this dissertation we study several problems related to the management of healthcare and the cure of disease. In every chapter a hospital capacity distribution problem is analyzed using techniques from operations research, also known as mathematical decision theory. The problems considered are inspired by logistical challenges faced by Leiden University Medical Center (LUMC). Several of the solutions we present in this dissertation have been implemented at LUMC as well.

Considering our aging population, shrinking workforce and the current hospital efficiency levels it will be difficult, if not impossible, to provide an appropriate level of care for the sick and the elderly in the coming decades. Given what is currently at stake, it is hard to understand that it is quite common in hospitals to avoid explicit decisions on resource allocation and capacity distribution and just anticipate on ad-hoc basis on problems that occur. This is sometimes accompanied with very undesirable system outcomes such as patient cancellations and extremely long access (the time the patient spends on the waiting list) or waiting (the time the patient spends in the hospital waiting) times. The models we present allow for a quantification of consequences of capacity distribution decisions. The item that is distributed can either be time, or another kind of resource such as staffed beds. With the models a clear and succinct understanding of the problem, its possible solutions, and implications of these solutions can be obtained.

This dissertation consists of three parts. The first part serves as an introduction and contains the Introduction Chapter, 1, and Chapter 2, which provides an introduction to queues, networks of queues, and their applications in healthcare.

In the second part of the dissertation we focus on challenges for outpatient clinics and diagnostic facilities. In Chapter 3 we study the reorganization of an outpatient clinic. We demonstrate how the involvement of essential employees combined with a queuing network model designed to support the decision making process results in a successful intervention. Key points in the intervention are the rescheduling of appointments and the reallocation of tasks.

Chapter 4 presents a methodology to develop appointment schedules for outpatient clinics with unscheduled (walk-in) and scheduled (appointment) patients. The goal is an appointment schedule that keeps waiting time at the facility for unscheduled patients below an acceptable level, while controlling the access time for scheduled patients. A

cyclic queuing and a Markov decision model are combined with an algorithm to determine an appointment schedule that satisfies all requirements.

Chapter 5 is motivated by the increasing popularity of care pathways in outpatient clinics. Hospitals aim to optimize the flow of patients in a care pathway by prioritizing them in the appointment planning process. As a result, regular patients who are not in a care pathway may experience increased waiting times. We develop a queuing model with a reservation scheme that allows for a trade-off between the accessibility for patients from the care pathway and waiting time for regular patients at an outpatient clinic.

In Chapter 6 we consider an MRI scanning facility run by a Radiology department. Several medical departments compete for capacity and have private information regarding their demand for scans. The fairness of the capacity allocation by the Radiology department depends on the quality of the information provided by the medical departments. We employ a game-theoretic approach that stimulates the disclosure of true demand, so that capacity can be allocated fairly.

In the last part we study challenges that evolve when urgent and elective patient flow meet. Chapter 7 studies the trade-off between cancellations of elective surgeries due to semi-urgent surgeries, and unused operating room (OR) time due to excessive reservation of OR time for semi-urgent surgeries. Semi-urgent surgeries, to be performed soon but not necessarily today, pose an uncertain demand on available hospital resources, and interfere with the planning of elective patients. For a highly utilized OR, reservation of OR time for semi-urgent surgeries avoids excessive cancellations of elective surgeries, but may also result in unused OR time, since arrivals of semi-urgent patients are unpredictable. We use a discrete-time queuing and a Markov decision model to smooth the planning process.

Using the methodology presented in Chapter 7, part of the OR capacity of the Neurosurgery department at LUMC was allocated to semi-urgent surgeries. In Chapter 8 we study the implementation process and the effect of dedicating OR slots to semi-urgent surgeries on elective patient cancellations and OR utilization.

A recent development to reduce ED crowding and increase urgent patient admissions is the opening of an Emergency Observation and Assessment Ward (EOA Ward). At these wards urgent patients are temporarily hospitalized until they can be transferred to an inpatient bed. In Chapter 9 we present an overflow model to evaluate the effect of employing an EOA Ward on elective and urgent patient admissions.